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ESSAY

on

NAUTICAL SURVEYING.

by

Dalrymple.

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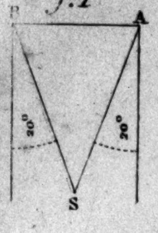

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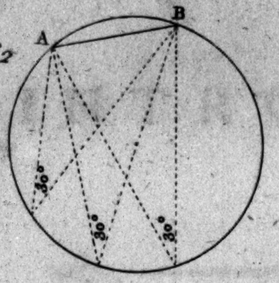

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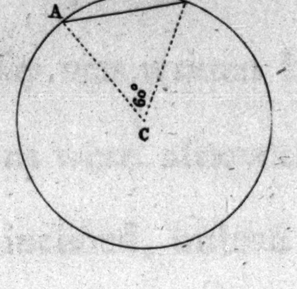

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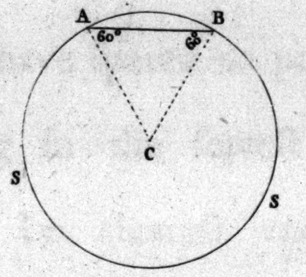

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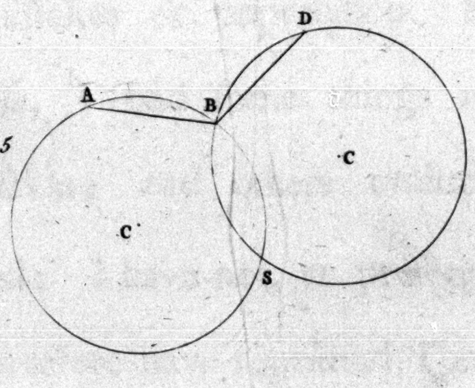

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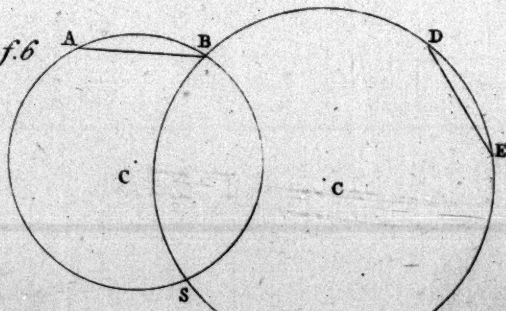

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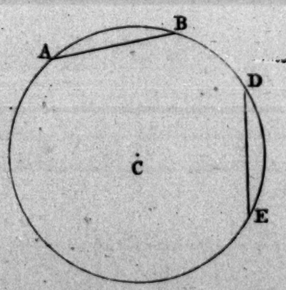

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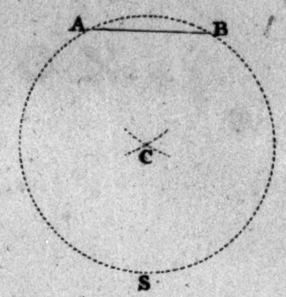

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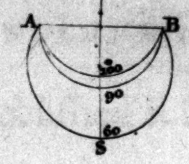

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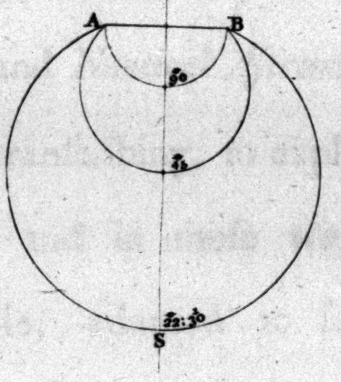

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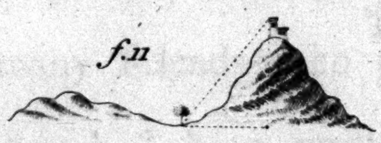

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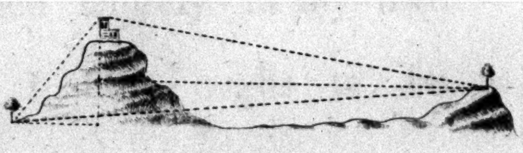

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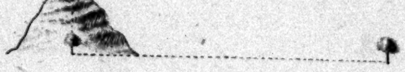

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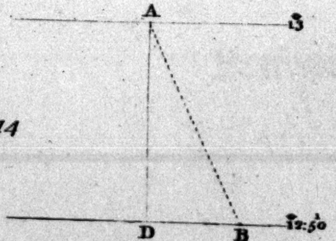

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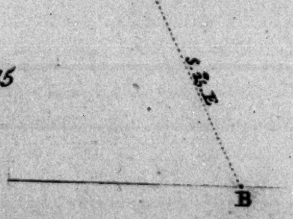

INTRODUCTION.

THIS Eſſay was written before I returned to ENGLAND in 1765; ſome additions were afterwards made, before I publiſhed it in 1771. I was much inclined, inſtead of now reprinting it, to have ſubſtituted an *Elementary* Treatiſe of *Practical Navigation* and *Nautical Aſtronomy*, in which I have ſpared no pains, by frequent tranſcribing, to explain every thing in the feweſt words poſſible, and in thoſe which appear to be cleareſt and moſt intelligible, adapted to ſuch Perſons as have no antecedent Knowledge of the Subject: and I have profited by the aſſiſtance of many Friends who pointed out miſtakes or unpreciſion. But, although I have written *this Treatiſe*, I find ſome things not expreſſed entirely to my own ſatisfaction; and others omitted, which I think ought to be inſerted: I have not, at preſent, leiſure to compleat this *Treatiſe*; and therefore have reprinted The *former Eſſay* on *Nautical Surveying*, with very little alteration.

Perſuaded that ſuch a *Treatiſe* of *Navigation* and *Nautical Aſtronomy*, as has been mentioned, would be very uſeful: I ſhall not loſe ſight of this Object, if an Opportunity ſhould offer of putting the finiſhing hand to *It*.

Dalrymple.

24th Febr. 1786.

ESSAY
On the
MOST COMMODIOUS METHODS
OF
NAUTICAL SURVEYING.

IT often happens that People are prevented from making any Obſervations of the Lands they ſee, from a Perſuaſion that they ſhall not have Opportunity to make ſuch as would be ſufficient to form even a Sketch of theſe Lands, and therefore that their Labour would be *in vain.* Others are prevented by *Diffidence*; but moſt are, from Negligence or Ignorance, remiſs in the Obſervations requiſite to compleat the Art of Hydrography. The Intention of this Eſſay is to aſſiſt and exhort the Former; to encourage the Diffident; to ſhame the *Careleſs*, by ſhewing *with how little Trouble* uſeful Obſervations may be made; and to inſtruct the Ignorant in the Practice of a few uſeful Rules.

It is poſſible nothing *new* may be found here; it is, however, imagined, ſome Things *uncommon* will be met with, and others diſpoſed in their proper Place, inſtead of being *loſt* in the Heap of practical Queſtions.

Experience has fully convinced me, that Bearings, taken by *Compaſs*, cannot be ſafely truſted to, in making a correct Draught.

I have found not only a Difference of 3° or more, in different Compaſſes, but in the *ſame Compaſs* at different Times: I do not ſay the *Effect* had no *Cauſe*, but there was no ſenſible one which I could diſcover: And I have heard other People ſay, their Obſervations gave room to believe, there is a *caſual Deviation conſequent to the State of the Atmoſphere, or ſome other occult Influence.*

Sometimes the Obſervations made with the Compaſs will correſpond very well with each other; it is not therefore my Intention to condemn the Uſe of it entirely; but if the Sea be rough, it is very troubleſome taking many Bearings by the Compaſs, as it requires much Time to be ſure the Compaſs ſtands true; ſo that the Uſe of the Compaſs, beſides other Inconveniencies, is attended with Delay, whereby the Lands loſe their reciprocal Situations, and by this Means, being as it were taken from different Stations, if the Objects be near, the Angles do not coincide in plotting the Draught. Beſides, the Rigging and Sails often intercept the Sight of the Objects, from the only convenient Part of the Ship where the Compaſs can be placed.

For taking Angles, the Hadley is as much preferable to the *Compaſs* in Facility, as Exactneſs. In the common Obſervation for finding the Latitude, the Hadley being held upright, the Index is ſlided forward till the Image of the Sun, by Reflection, touches the Horizon ſeen by direct Viſion: For taking Angles, the *Hadley* is held horizontal, and one Object by *Reflection* brought, by moving forward the Index, to coincide with another ſeen by *direct Viſion.*

If the Compaſs could be relied on, Bearings taken by it have one Advantage over the Angles taken by Hadley, *viz.* That theſe Bearings, being the Angles from the Magnetick Meridien, are eaſily laid down by the Meridien in the Chart; for ſuppoſing A to bear N 20° E, and B N 20° W, from an unknown Station; laying off the Fig. 1. reverſed Bearings S 20° W from A, and S 20° E from B, the Interſection would give the Station, which cannot be found by *two Objects* with any other Inſtrument; all Inſtruments for meaſuring Angles, except the Compaſs, requiring *three* Objects to determine the Station: Indeed, the *North* Point of the Compaſs may be conſidered as a *third* Object when this inſtrument is uſed.

The Compaſs is alſo very uſeful in ſetting Points as they come *in one*; but there are many Occaſions when a Compaſs cannot be uſed with any Accuracy, where a Hadley is extremely commodious and equally exact.

All Compaſs Obſervations made in Boats are liable to great Objection; the Motion of a Boat will ever prevent Exactitude in Compaſs Bearings, [a] and the Extremities of Shoals and the Depths in intricate

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[a] It is ſaid *Wright's* WATER-COMPASS ſtands perfectly in a *Boat*. I find the following Account, in The *Navigator's Supply*, by *William Barlowe*, 4° London, 1597. "Some "few years ſince it ſo fell out, that I had ſeveral conference with two Eaſt Indians, which "were brought into England by Maſter Candiſh, and had learned our language; The "one of them was of *Mamillia*, [Manila] in the Iſle of *Luzon*, the other of *Miaco* in "*Japan*. I queſtioned with them concerning their ſhipping, and manner of ſailing. They "deſcribed all things far different from ours, and ſhewed, that inſtead of our Compaſs, "they uſe a Magnetical Needle of ſix inches long, and longer, upon a pin, in a diſh of "white *China* Earth filled with water; In the bottom whereof they have two croſs lines, for

"the

intricate Channels, (for determining which, Boats are uſually employed) require the minuteſt Exactneſs. In ſuch Caſes, the Uſe of the Hadley removes every Difficulty; for if the reciprocal Situations of any *three* Objects are known, the Compaſs Bearings are not neceſſary; and if there are not *three* Objects which can be uſed for this Purpoſe, the Bearing of the Boat may be taken from the Ship on making a Signal; and this, reverſed, will give the Bearing of the Ship from the Boat, which may then uſe the Ship as an Object, and lay off the other Angles equally, as if they could have been taken exactly by *Compaſs*.

I have ſometimes uſed the ⊙ *Amplitude*, inſtead of the *Compaſs*, for taking *Bearings*, by meaſuring the Angle from the ⊙ *Limb* to ſome *Point* on the *Land*, this is very convenient, as it gives the *true Bearing* free from *Magnetic Variation*, or any *Accidental Error* of *Compaſs*. On mentioning this to the *Aſtronomer Royal*, He obſerved that the ⊙ *azimuth* might be uſed for the ſame purpoſe, taking care to meaſure a *wide angle*, to prevent any error ariſing from the ⊙ *Altitude*, if it ſhould not be thought neceſſary to correct by it: This, however obvious, never occured to me, and therefore it ſeemed proper to mention it here, leſt it may equally eſcape others. Uſing the ⊙ has all the advantages, before recited, of Bearings by Compaſs, The true Place of the ⊙ being equivalent, in effect, to a *third* Object.

All

" the four principal winds; The reſt of the diviſions being reſerved to the ſkill of their " Pilots. Upon which report of theirs, I made preſent trial how a Magnetical Needle " would ſtand in water, and found it to prove excellently well; not doubting but that " many concluſions of importance, in Marine Affairs will thereby more readily be performed."

All Bearings or Angles of very near Objects, are liable to Incertainty from the Sheering of the Ship, as that Alteration will make a Difference in the Poſition of *very near* Objects. Obſervations made in Boats at Anchor are leſs liable to Error, as the Change of Place is ſmaller; and, either in a Ship or Boat, the Obſervations made by the Hadley, will be more exact than thoſe by Compaſs, as performed more expeditiouſly.

In Surveying, the *real Diſtance* is the direct Diſtance from one Place to another; the *apparent Diſtance* is the Angle under which two Objects are ſeen. The moſt uſeful Problem in Surveying is, " to find a *Station*, by obſerved Angles of three or more Objects, " whoſe reciprocal Diſtances are known, but Diſtance and Bearings from the Place of Obſervation unknown."

Fig. 2. Two objects can only be ſeen under the ſame angle from ſome part of a *circle* paſſing thro' thoſe objects and the place of obſervation.

If the angle under which thoſe objects are ſeen be leſs than 90°. the place of obſervation muſt be ſomewhere in the *great Segment*, and thoſe objects will be ſeen under the ſame angle from every part of that Segment.

If the angle under which thoſe objects are ſeen be more than 90°. the place of obſervation will be ſomewhere in the *little Segment*, and thoſe objects will be ſeen under the ſame angle from every part of that Segment.

The angle under which two objects appear in the *great* Segment, will be as much *leſs* than 90°. as the angle under which thoſe objects appear in the *little* Segment is *above* 90°.; and conſequently the angle under which thoſe objects appear in the *little* Segment, will be as much *more* than 90°. as the angle under which they appear in the *great* Segment is *leſs* than 90°.

Fig. 3. The angle at the Center is always double the angle at the Circumference of the great Segment.

Fig. 4. And conſequently if two objects A B be ſeen under an angle of 30°. from ſome unknown ſtation S; theſe objects will be ſeen under an angle of 60°. at the Center of a Circle paſſing through A B and S.

If the two objects A B are ſeen under an angle greater than 90°. they will appear from the Center under the angle which double the angle obſerved wants of 360°. Ex: ſuppoſe Angle obſerved 150°. double 300°. taken from 360°. remains 60°. the angle at Center.

The three angles of a plain Triangle are equal to two right angles or 180°. and therefore the difference between 180°. and the angle at the Center will be the ſum of the two other angles.

Fig. 4. Ex: Take the difference between the angle at Center C (ſuppoſe 60°.) and 180°. and *half* that difference will be the angle B A C = 60°. or angle A B C = 60°. Or

Take the difference between the angle obſerved and 90°. and that difference will be the angle B A C or angle A B C; which angles laid off from A and B the interſection will be the point C, which is the Center of a Circle paſſing through A B and S.

As the ſtation S. muſt be ſomewhere in this Circle, it is therefore obvious, if the ſame operation was repeated with the angle under Fig. 5. which are ſeen two objects, whoſe reciprocal ſituations to A and B are known, that the interſection of this Circle with the former would give the point of obſervation S.

One

Fig. 5. One of the objects A or B may be uſed in the ſecond operation, Fig. 6. but it may be performed by two new objects D E.

If *two* known objects be ſeen in *one* line, the ſtation from whence they are ſeen may be found by *one* angle made by them and ſome other object, for having drawn the Circle correſponding to this angle (as deſcribed fig. 4) a line drawn through the *two* objects ſeen in *one*, will interſect the Circle in the ſpot where the Station falls, in the ſame manner as another Circle would (Fig. 5.)

Fig. 7. But if the three or more objects are in the ſame Circle, there will be no ſolution, as the Center will be a common Center to both Circles; and therefore no Interſection to determine in what part of the Circle the point S will fall.

It muſt alſo be obvious, that in uſing four objects, the two Circles will interſect each other in two places, but there can be no difficulty of determining which Interſection is the Station.

Although this is a very ſimple ſolution of the problem by Projection, I think the following by the Logarithm Tables is preferable.

As Sin. Half angle at Center
To Half the diſtance between the two objects A B
So is Radius
To A C or B C

This diſtance laid off from A and B, by a Scale of equal Parts, the Fig. 8. Interſection will be the Point C, which is the center of a Circle paſſing through A B S.

My ingenious Friend, the Reverend Mr. Michell, in a paper on this ſubject, ſays, if the line drawn from A to B, be *biſected* by an *indefinite* Right

Fig. 9. Right line *perpendicular* to A B; the *Tangent* of the Angle between the *obſerved Angle* and 90° laid off on this *indefinite Line*, from the point of *Biſection*, will on that Line give the Center of a Circle paſſing through A B and S, or Place of Obſervation. It muſt be obvious if the obſerved Angle be 90°, the Point of *Biſection* will be the Center of *the Circle*; if the Angle obſerved be leſs than 90° the Tangent muſt be laid off on the *indefinite line*, ſo that the Objects A and B appear to Right
Fig. 9. and Left of each other as in the Bearings, by which the Segment will come *without that Circle*, if the Angle obſerved is more than 90° the Tangent muſt be laid off on the other ſide of the Line A B, ſo that the objects A and B appear differently from what they were in the Bearings, that which was on the Right being to the Left, thereby the Segment will come *within that Circle*.

This Method of Mr. Michell's appears preferable to all others, becauſe the Centers of the Circles, or Segments, correſponding to every obſerved Angle are eaſily deduced, after the firſt Operation *of drawing the indefinite Line perpendicular* to A B, by marking on this *Line* the Tangent of the Angle, between the Angle obſerved and 90°; whereas, in the other Modes, the ſame Operation is to be performed to find a Center to every Circle, without any Aſſiſtance being derived from the former Centers found. Beſides, in Mr. Michell's, having found the Center to the Segment of one Angle, the interſection of the indefinite Line by that Segment, gives the Center of a Segment correſponding to Half that Angle. Thus the *Point*, where the Segment of 90° interſects the *indefinite Line*, is the Center of a Segment of 45° or *Half the Angle*; where the Segment of 45° interſects the *indefinite Line*, is the Center of a Segment of 22° 30′, &c. and therefore if the difference between the Angle obſerved and 90° be more than the ſcale of Tangents contains, find the Center to double the angle obſerved, and the point where the Segment from that Center cuts the indefinite line, will be the Center of the Segment required. Fig. 10.

It has been already obſerved, that no inſtrument is ſo commodious for taking Angles as the Hadley. It is uſed with equal Facility at Maſt-head as upon Deck, and therefore the ſphere of Obſervation is by this inſtrument much extended. For ſuppoſing many Iſlands are viſible from Maſt-head, and only *one* from Deck, no uſeful Obſervations can be made by any other inſtrument; becauſe Compaſs Bearings from Maſt-head can only be taken very vaguely, and a ſmall Error in the Bearing of a diſtant Object, makes a great Error in its Poſition; but by the Hadley the Angles may be taken at Maſt-head from the *one* viſible Object with the utmoſt Exactneſs. Beſides, taking Angles from Heights, as Hills, or a Ship's Maſt-head, is almoſt the only way of exactly deſcribing the Extent and Figure of Shoals.

It has been objected to the Uſe of the Hadley for Surveying in general, "that *it* does not meaſure the *horizontal* Angles, "by which *alone* a Plan can be laid down." This Objection however *true* in *Theory*, may be removed, in *Practice*, by a little Caution, which in the obſervations made from *Heights*, is very requiſite.

If an Angle is meaſured between an Object on an Elevation, and another near it in a Hollow, the Difference between the *Baſe*, which is the horizontal Angle, and the *Hypothenuſe*, which is the Angle obſerved, may be very great; but if theſe Objects are meaſured, not Fig. 11.

from each other, but from ſome very diſtant Object, the Difference between the Angles of each from the diſtant Object will be very nearly the ſame as the horizontal Angle. Beſides, a Correction may be made by meaſuring the Angle, not between an Object on a Plane and an Object on an Elevation, but between the Object on a Plane, and ſome Object in the ſame Direction as the elevated Object, of which the Eye is ſufficiently able to judge. Fig. 12. Fig. 13.

In deſcribing Shoals from an Elevation, the greateſt Attention to this Matter is requiſite; but it is ſo obvious in Practice, that Nothing more than a Caution on the Subject is neceſſary.

The Horizon being an equidiſtant Line, the reciprocal Diſtances may be found by the Depreſſion of the Horizon to Objects ſeen within it.

Although the Hadley will ſhow, by the Depreſſion of the *Horizon*, the reciprocal Diſtances, it will not give any Data for laying Places down; which, however, may be done by a *Land Quadrant*, as the Level gives a *parallel* Line to the Surface of the Sea, to which the Zenith will be at Right Angles, and the Angle of Depreſſion of the *Horizon* to other Objects, will interſect the *Line* of the *Surface* of the Sea at the Diſtances where theſe Objects lye; for meaſuring which Diſtances, the perpendicular Elevation of the Place from whence the Obſervations are made, will be a Scale; and this *Elevation* will be ſhewn by the *Barometer:* but in this I mention my ſuppoſition, not practice. For this Purpoſe a Card with a graduated Circle, the Diameter being divided into equal Parts, will be very uſeful for marking on the

Spot where Objects fall. This Card will alſo be very uſeful in determining the Extent of Objects from their Bearings and Diſtances, in which the Eye is generally miſtaken, by ſuppoſing the Extent greater than the Angle will admit, particularly in the Extent of Breakers.

As an Example of the Method of expreſſing the Angles taken by the Hadley, I ſhall give thoſe taken from the Top of the Iſland *Corejidor*, at the Entrance of *Manila Bay*, as a Proof how very near the Sum of all the Angles will be to 360°, even where the Objects are very much out of the horizontal Plane; for although the Elevation of *Corejidor* above the Sea is very conſiderable, and the Altitudes of the Objects obſerved very unequal, and ſome of them greatly depreſſed under the Horizon, the Sum of the Angles is only 0° 15′ or ¼ of a Degree deficient of the compleat Circle 360°.

As the Object by reflection is uſed for ſeveral Angles, I mark it *, and ſet down the obſerved Angles to the Right and Left as below:

* 1ſt *Limbones Ears*, *per* Compaſs S. 23° ½ E.

R 36° 30′ *Fortun* * 5th	*L* 48° 10′ *P° Cavallo* * 2d
* 5th *Fortun*	* 2d *P° Cavallo*
R 71 20 *Monja*, per Compaſs W 5° S.	*L* 91. 45 *Cabcaben* Point * 3d
	* 3d *Cabcaben* Point.
107. 50	*L* 90. 40 *Dolphin's Noſe* * 4th
251. 55	* 4th *Dolphin's Noſe*
	L 21. 20 *Monja*
359. 45	
360. 00	251. 55
0. 15 Deficiet	

I have not inſerted any Angles here but ſuch as were uſed for continuing the Obſervations. As the Quadrant will not meaſure more than 90°, it is requiſite, when it will meaſure no further [a], to change the Line of Obſervation, which I mark * 2d, * 3d, &c. In this Example the Angles are all ſet down juſt as they were *obſerved*, except that between *Limbones Ears* and *Fortun*, the Angle meaſured from *Fortun*, was not to *Limbones Ears*, but to *Fraile*, which was 49° 30′; but as *Fraile* was found to be from *Limbones Ears* 13. 00 the other Way, the Difference of theſe two Angles 36. 30 muſt conſequently be the Angle from *Fortun* to *Limbones Ears*.

I ſhall not give any further Example, but obſerve that it is not only ſatisfactory but uſeful, to continue the Angles round the Circle; becauſe if the Sum of all the Angles does not amount to 360°, it points out an Error in ſome of the Angles of thoſe Objects uſed as Lines of Obſervation.

It is further to be obſerved, that neither a *near Object*, nor a *low Point*, ſhould ever be uſed as a *Line of Obſervation*; for the Difference of Refraction of the Air, or the Elevation and Depreſſion of the Ship by the Tide, or even by the *Send* of the Sea, will change the latter, and, conſequently, make the whole Chain of Angles, taken from this *fluctuating Line of Obſervation*, diſagree; and the Sheering of the Ship will have the ſame Effect in the former Caſe.

The beſt Object for an Obſervation Line is a *ſharp Peak*, a *bluff Point*, or any *remarkable* Thing at a *Diſtance*, which can at all Times be certainly diſtinguiſhed.

Having now diſcuſſed the Uſe of the Quadrant, I ſhall briefly mention ſome other Matters which, though extremely uſeful in Practice, may not occur to every one.

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[a] The *Sextant*, which is now commonly uſed, will meaſure to 120°, and *Hadleys* are made to meaſure above 130°.

The Baſis of all Surveying is in determining a Diſtance; for unleſs ſome Baſe is found, or *aſſumed*, no Chart can be made.

It very ſeldom happens that there is an Opportunity of meaſuring ſo long a Baſe *aſhoar* as to be uſeful in conſtructing a Chart; but the *Reſult* of ſmall Triangles from a ſhort Baſe, will form one with ſufficient Exactneſs. This Method, though obviouſly preferable to Obſervations merely from Ship-board, is not recommended in any Treatiſe of Marine Surveying, which may, perhaps, ariſe from a Preſumption that it would naturally occur. It is, however, liable to Exception where the Coaſt is low or circular; it is alſo impracticable where the Coaſt is in a direct Line, unleſs there be remarkable Lands *in-Shoar:* However, in all Coaſts which have deep Trenchings or Iſlands in the Offing, and, conſequently, amongſt Iſlands it is very commodious.

There is a very eligible and convenient Method of ſurveying a River, particularly where there is Ground to imagine Offence might be taken at any open Remarks, *viz.* by *Warps*, whoſe Length being known, give a Baſe. A like Method is uſeful in determining the Extent of ſmall Shoals, by letting-go a Grappling on the Extremity, and veering away till the Boat reaches the other End.

But the beſt Method of meaſuring Diſtances for Hydrographical Purpoſes is by Sound. The Rate of the Motion of Sound is by the moſt accurate Obſervations determined to be 1142 Engliſh Feet in a *Second* of Time, or 6120 Feet, which is a Nautic or Geographic Mile in $5'' \frac{1}{3}$ nearly; ſo that making a Half-Second Pendulum, (with a Plummet at the End of a Thread of 9 Inches $\frac{8}{10}$,) each Stroke will be equal to 571 Feet; which multiplied by the Number of Strokes from ſeeing the Flaſh, or Exploſion, till hearing the Report, will give the Diſtance in Feet. In ſmall Diſtances this Method is not preciſe enough, for it is obvious no leſs Diſtance than 571 Feet can be diſtinguiſhed; but in conſiderable Diſtances, as 2 to 5 or 6 Miles, it is ſufficiently exact. For as 2 Miles are equal to 12,240 Feet, the Amount of *one Stroke* is not $\frac{1}{21}$ Part of the Diſtance, or $\frac{1}{10}$ of a Mile difference in 2 Miles; and in larger Diſtances the Difference is ſtill ſmaller. It is moſt expedient to take the Report of ſeveral Guns to prevent any Miſtake. This Method may be very uſefully employed in meaſuring a Baſe between *two* Veſſels, who, taking the Bearings at one Time of each other and the ſame Objects, will determine their Poſitions with the utmoſt Exactneſs; and the Baſe may be proved by both Veſſels firing, and the Perſons a-board each, afterwards comparing their Eſtimations of Diſtance.

There is another Method which has its Uſe, where a *ſingle* Veſſel is on a Coaſt, *viz.* by making the *Obſerved Latitudes* a Baſe, on a Coaſt not very devious from Meridional, the Tranſient Bearing[a] of the Points, &c. and the Latitude obſerved, will determine the Poſition with ſufficient Preciſion. This Method will be fully explained by an Example.

A, when it bore E, was found by an Obſervation of Latitude to lye in	13° 0′ N
Ƀ was ſet in one with it, S 25° E	
B, when it bore E 2° N. was found by an Obſervation to lye in	12. 50 N
Fig. 14. Difference of Latitude or *Side* AD=	00. 10

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[a] By *tranſient Bearing*, I mean when two Objects come in one Line.

The Nº or Sº Line which marks the Difference of Latitude between A & B muſt be at right Angles to the Parallel of Latitude of the laſt Object; and therefore in the Triangle are given *Side* AD= 10.

angle DAB= 25° 00′.
angle ADB= 90. 00.
115. 00.
180. 00.
Fig. 14. angle ABD= 65. 00.

Then as angle ABD 65° 0′ : AD 10′. : : Rad. : AB.

Fig. 15. Or it may be laid down by the Bearing S 25° E, laid off from A, till it interſects the other Parallel of Latitude, which is the Point B.

It is here to be obſerved, that the Bearing muſt be the *true*, not the *magnetick*.

It is evident the reverſed Bearings of any known Object, not near the *Parallel*, will determine a Station by interſecting the Latitude obſerved, and that the Interſection of Bearings from *two ſuch Stations* determines, as nearly as Bearings by *Compaſs* can determine, the preciſe Place of every Thing they lay down. But this Method, which requires an uninterrupted Series of *obſerved Latitudes* and *tranſient Bearings*, is only to be uſed by a Perſon in *coaſting*. Different Eyes, different Inſtruments, and various Accidents, make Obſervations of Latitude too precarious Data for general Uſe, though extremely convenient in running down a Coaſt where the Points are prominent, where there are Iſlands in the Offing, or remarkable Lands in-Shoar. But a Coaſt may be ſo formed that a very ſmall Diſtance ſhall open one and ſhut-in another Point, and conſequently the Number of neceſſary *Obſervations* of Latitude become almoſt infinite. In ſuch a Coaſt, if there be no Iſlands or remarkable Lands to continue the Series, the Method is ſcarce applicable. The ſame Inconvenience in ſome Meaſure attends low Shoars, as they confine each Day's Run to the Diſtance the Eye can reach. Tho' this Method be eligible in a Coaſt nearly *Meridional*, it becomes leſs exact as the Coaſt diverges from this Direction, and at laſt is of no Uſe.

Capt. Plaiſted's Practice of uſing, for determining the Courſe and Diſtance in *Soundings*, a Lead inſtead of a Log to his Line (the ſtray Line correſpondant to the Depth of Water) ſeems to be a good Method of correcting the Log.

Middleton, who was employed in the N W Diſcovery, mentions his being accuſtomed to try the Current when laying-to under a Main-ſail: The Hudſon's Bay Ships commonly try it in eaſy Weather by a current Log. “ This is a Quadrant of a Circle about 30 Inches “ diameter, ſlung like a common Log with Lead let into the Circle “ Rim ſufficient to ſink it; then at the Diſtance of 70 or 80 Fathom “ on the Line is faſtened a Cork, or any light Thing that will ride “ the Log that is ſunk, and to this Buoy the Line is to be faſtened “ as in common Uſe to the Log, with ſufficient ſtray Line to go “ clear of the Ship or Boat, the Remainder of the Line being “ marked as the Log-line, it will be eaſy to determine the Ship's “ Courſe by the Bearings of the *Float*, and the Line gives the Diſtance[a].”

It is neceſſary to take Care that the Line on board does not check the Float, but this is equally neceſſary in uſing the common Log. The Hudſon's Bay Ships uſe a Stone Bottle for the Float.

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[a] Extract of a *Letter* from a *Hudſon's-Bay Captain.*

This Method gives the Ship's *Drift*, but does not ſhew what is the Direction and Velocity of the Current. For determining this, Middleton informed me, he, at the ſame Time, hove the Common Log, and by it found the Ship's Courſe and Diſtance without any Allowance for Current, and, conſequently, the difference of the two Meaſurements is the Current. He alſo told me that his Log-reel had braſs Cogs.

Perhaps, Nothing is more eaſy or more exact than this Method; but in Juſtice to Middleton's Memory I muſt ſay, I never heard of any Body elſe uſing it. In his Publications he does not explain what Means he uſed, but very freely communicated his Method of Practice to me, on a Viſit I made to him for this Information.

There is another very uſeful Method of correcting the Log in ſight of Land, which firſt occurred to me on the Coaſt of Celébes, in 1761, *viz.* by the Bearings of the Land; An Example will render this familiar.

At Noon.	An Iſland A. bore	E 34° 30′ S.
	Rock B, ...	E 20. 30 S.
	Courſe per Log to Noon following .	E 11. 00 S.
	A. then bearing	E 55. 30 S.
	B.	E 15. 00 S.
	The Courſe made good was evidently between	E 34. 30 S.
	And	E 20. 30 S.

(inſtead of E 11°. S. as per Log;) for

A. now bearing 21°. *more* to the *Southward* than before, the *Courſe* muſt have been *leſs Southerly* than its Bearing . . . . . E 34°. 30′. S.

Rock B. bearing now only . . E 15. 00 S.

or 4°. 30′. *leſs Southerly* than its former Bearings, evinces the *Courſe* to have been *more Southerly* than its Bearings E 20. 30 S.

Suppoſe at the firſt Noon C. bore . E 25. 00 S.

and to have the ſame Bearings at the ſecond Noon, it would ſhew the Courſe to have been . . . E 25. 00 S.

but even ſuppoſing no Object remained in the ſame Bearings, the eſtimated Diſtances would ſhew nearly the *true Courſe*, by a Compariſon of the Alteration of the Bearings of the different Objects. This Method purſued will give the Courſe very nearly exact; for, if ſeveral Objects be ſet, it may be poſſible to determine the Courſe to as great a Preciſion as Hydrography requires; and if the Courſe be well determined, the Bearings taken from frequent Stations will, with Care and repeated Trials, work themſelves right. For this Purpoſe it is recommended to repeat the ſeveral Bearings every Hour, by which Means the Number of Stations will greatly facilitate the Reſult. It is not neceſſary to take more than *one* Bearing from each Station by Compaſs; the other Angles may be taken by the Hadley.

And here it may be proper to obſerve, that the Angles taken by the Hadley are uſeful, although the *reciprocal* Situations of the Objects, whoſe Angles are taken, be not known; as theſe Obſervations may be made Uſe of, whenever the reciprocal Situations of thoſe Objects are found. I mention this chiefly with a View to *Soundings*, as a very little Trouble taken with the Boats of every Ship which paſſes the *Straits* of *Malacca*, &c. would afford Materials to conſtruct a very accurate Chart; although from not knowing the exact Situations of any Places in thoſe Straits, and a general Want of Attention, notwithſtanding the many Ships which paſs them annually, there is ſcarce any Improvement made in the Charts.

I think it would be very uſeful in Hydrography, beſides the Chart deſcribing the *Coaſts*, *Soundings*, &c. to have one, on the ſame Scale, of *Lines* and *Points* only. For, as it is almoſt impoſſible in a Chart to have every Place or Sounding fixed with equal Preciſion, it is certainly expedient to ſhew, upon what Authority every Part is determined.

1. I would have the *Data* for determining the ſeveral Stations marked by *ſtrong Black Lines*.

2. The Bearings from theſe Stations for determining the ſeveral *Points* or Objects in *faint* Black Lines.

3. The *Points* or Objects whoſe Situations are determined with the utmoſt Preciſion I would mark *.

This kind of Chart would enable any one to lay down their Stations and Soundings, to be transferred into the other Chart, that it might be compleated and corrected.

The Obſervator ought to be very minute in his Soundings, taking, if he can, the Angles by the Hadley of *three* * Objects, ſeperated from each other at leaſt 20° If one Bearing be taken by Compaſs, it will facilitate the Projection; but if the Soundings be of conſequences it will be moſt eligible to project them from the Angles taken by the Hadley only: The ſame to be obſerved in determining or correcting the Situation of any remarkable Point unaſteriſked. If *three* proper * Objects cannot be had for determining any Station, *more* than *three* unaſteriſked Objects ought to be taken; and, in general, it is to be obſerved, the greater Number of Angles are taken, the greater will be the Probability of Exactneſs.

It muſt be obvious the Things requiſite to compleat ſuch a Chart, would be.

1. Obſervations to corroborate or correct *unaſteriſked* Points, that they might be *aſteriſked*.

2. Obſervations to compleat the Soundings.

3. Obſervations to determine the Situation of Places not before laid down.

All require great care, but none ſo much as the Obſervation to *aſteriſk* an Object, as an Error herein might induce many, by uſing this Object, to determine other Stations.